REMARKS

Claims 1-13 and 18-53 are in the application. Claims 14-17 have been canceled, without prejudice. New claims 42-53 have been added. No original claims were amended.

1. §102 Rejections

Claims 18, 19, and 35 have been rejected under 35 USC §102(b) as anticipated by Konno '438.

Regarding claim 18, in relevant part the Examiner contends that Konno '438 teaches: (a) an optical waveguide having a core fabricated from a glass having a softening point (inherent), and (b) a lens fabricated from glass *having a softening point less than the softening point of the core*. For support of this proposition, the Examiner cites column 8, lines 58-60 and 64-67, which read as follows:

> More specifically, the tip of the optical fiber terminal of this invention is constructed as shown in the FIG. 1(*a*) example. It comprises an SiO_2 fiber lens tip 7, a pigtailed main fiber 8, a ferrule 9 for protecting the tip 7, and a tip lens 10. It is also feasible to omit ferrule 9. FIG. 1(*b*) shows the transmission state of the beam; when the distance to the convergent point of the beam (beam waist) emitted from the SMF main fiber 8 is z, and the refractive index of SiO_2 at the wavelength λ is n, the Gaussian beam expansion for the beam propagating though the fiber lens 7 is shown by Formula 1. (Konno '438, column 8, lines 57-67.)

Konno '438 therefore discloses a standard single mode fiber (SMF) which is presumably fabricated from an SiO_2 glass likely having a germanium-doped core (though optical fibers having other core and cladding dopants were known in 1991), and a lens member also fabricated from an SiO_2 glass.

The cited portions of Konno '438 therefore do not appear to explicitly or implicitly teach a lens member fabricated from a glass that has a softening point less than the softening point of the core of the optical fiber. For this reason, Konno '438 doe not anticipate the invention as recited in claim 18. Claim 19 would be allowable as depending from claim 18.

Regarding claim 35, in relevant part the Examiner contends that Konno '438 teaches *a method of forming said lens member that includes retracting the ferrule.*

Claim 35 recites a method for fabricating an optical fiber lens assembly including the step of "retracting the optical waveguide through the bore [of the ferrule] *such that a portion of the lens member contacts the end surface of the ferrule.*" (Emphasis added.)

The disclosure of Konno '438 appears to teach forming a lens on an optical fiber pigtail and inserting that pigtail into a ferrule. But more importantly, Konno '438 teaches that when the lens assembly is placed into a ferrule, the fiber and lens element are separated from the ferrule by an "optical fiber protecting material 31." (See Konno '438, column 14, lines 54-61; FIG. 25.) This optical fiber protecting material 31 encompasses both the fiber and the lens, and insulates the fiber and lens from contact with the ferrule. The optical fiber protecting material 31 is distinct from the elements of the ferrule

The lens member therefore does not appear to contact the end surface of the ferrule in Konno '438, and claim 35 is not anticipated by Konno '438.

2. §103 Rejections

Claims 1-13, 20, 21, 25-34, and 36-41 have been rejected under 35 USC §103 as being unpatentable over Konno '438 in view of Miller '653.

The Examiner contends that Konno '438 discloses the limitations of claims 18, 19, and 35 as previously discussed, and further discloses several other elements or limitations listed on page 4 of the Office Action. The Examiner states that Konno '438 fails to teach, among other features:

(a) a lens formed from borosilicate glass or 4 wt% borosilicate glass;
(b) a throat portion of the lens member having a diameter greater than the waveguide;
(c) a throat portion of the lens member having a diameter greater than 135 microns;
(d) a throat portion of the lens member having a diameter greater than 200 microns; and

(e) a throat portion of the lens member having a diameter greater than 1.5 times the diameter of the waveguide.

First, Applicant notes that Konno '438 does not in fact teach all of the elements or limitations recited in claims 18 and 35, as discussed above.

Second, Applicant respectfully asserts that the Miller '653 patent should not properly be regarded or applied as an analogous prior art reference.

The ultimate issue is whether the invention as claimed would have been obvious from the combined teachings of the prior art. This legal determination is made against a background of several factual inquiries, one of which is the scope and content of the prior art. *Graham v. John Deere Co.*, 383 U.S. 1 (1966). Determining what is properly the "prior art" is a prerequisite to evaluating whether the differences between the claimed subject matter and the prior art are such that the claimed subject matter would have been obvious to a person of ordinary skill at the time the invention was made. *Id.*

This is frequently framed in terms of whether or not a given prior art reference is properly considered "analogous" (i.e., whether the reference is "too remote to be treated as prior art.") *In re Sovish*, 769 F.2d 738, 226 USPQ 771 (Fed. Cir. 1985); *In re Deminski*, 796 F.2d 436, 230 USPQ 313 (Fed. Cir. 1986); *In re Clay*, 966 F.2d 656, 23 USPQ2d 1058 (Fed. Cir. 1992). Two criteria have evolved for determining whether prior art is analogous: (1) whether the art is from the same field of endeavor, regardless of the problem addressed, and (2) if the reference is not within the inventor's field of the endeavor, whether the reference still is reasonably pertinent to the particular problem with which the inventor is involved. *In re Deminski, supra*; *In re Clay, supra.*

The Miller '653 reference is clearly not within the Applicant's field of endeavor. The claimed subject matter relates to fabricating a collimating micro-lens which is integrally formed on the end of an optical fiber, and can be used in micro-optic components where light passes from a fiber through an optical element and into another fiber equipped with a similar focusing micro-lens. In contrast, the Miller '653 patent relates to a *bulk* optical lens used in graphics or media projectors, such as a movie projector or slide projector. Although Miller '653 also discusses using the lens in light

projectors that employ LCDs or fiber optic arrays, this is much different than an optical fiber collimator micro-lens. Miller '653 relates to optical projectors in which white light is projected through an intermediate image (e.g., a movie, slide, or LCD), or where an image is generated and transmitted by a light-producing element (e.g., an LCD or fiber optic array). The lens is spaced apart from an electric bulb having a parabolic reflector, not integrally formed on or even fused to an optical fiber.

Applicant respectfully contends that Miller '653 is being cited because it describes a borosilicate glass lens and happens to use the term "fiber," but is not in fact within Applicant's field of endeavor.

Even though Miller '653 is not within Applicant's field of endeavor, it might still be properly combined with Konno '438 *if* Miller '653 were reasonably pertinent to the problem that Applicant was attempting to solve. *In re Deminski, supra*; *In re Clay, supra*. A reference is reasonably pertinent (even though it may be in a different field of endeavor) if it logically would have commended itself to an inventor's attention when considering the problem due to the subject matter with which the reference deals. *In re Clay, supra*. The purposes of both the invention and the reference are important when evaluating whether the reference is reasonably pertinent to the problem the invention attempts to solve. *Id.* If a reference has the same purpose as the claimed invention, the reference relates to the same problem, and this fact supports using the reference in an obviousness rejection because an inventor may well have been motivated to consider the reference when making his invention. *Id.* Conversely, if the reference is directed to a different purpose, the inventor would accordingly have had less motivation or occasion to consider it, and it may properly be regarded as non-analogous. *Id.*

It is readily apparent that Miller '653 is also not reasonably pertinent to the problem that Applicant was attempting to solve. Applicant's invention relates to fabricating a collimating micro-lens on the end of an optical fiber, and to enhancing the fabrication and performance of such an integral lens-fiber assembly. As such, Applicant was concerned with the physical and material characteristics of the fiber and lens elements, the splicing of the glass lens blank to the fiber, the formation of the desired lens shape, and the optical properties of the resulting lens-fiber assembly. In preferred

embodiments, the invention is described with reference to the geometric differences between the fiber and the throat of the lens to which the fiber is spliced, and the relative softening points of the fiber core and lens glasses which are fused together.

In contrast, Miller '653 does not contain any teachings relevant to the attachment, compatibility, or optical performance of an integral lens-fiber assembly. Miller '653 discusses a bulk optic lens that is spaced apart from an electric bulb and parabolic reflector. It is no more pertinent or analogous that a similar lens contained in a flashlight or an automotive headlamp.

For these reasons, Applicant submits that the Miller '653 patent is not analogous art, and its use as a reference in rejecting claims 1-13, 20, 21, 25-34, and 36-41 is therefore not appropriate. Applicant requests that the rejection be withdrawn.

Furthermore, while the Examiner suggests that Miller '653 generally teaches a borosilicate glass lens, there is no teaching or suggestion in the references themselves that would motivate one of skill to use a borosilicate glass when fabricating a lens-fiber assembly. Miller '653 does not suggest any advantage to using a borosilicate glass having a specified softening point relative to the softening point of the core of the corresponding optical fiber, nor of altering the diameter of the lens throat relative to the diameter of the fiber. Miller '653 further does not teach or suggest using a 4 wt% borosilicate glass for any purpose.

Claim 22 has been rejected under 35 USC §103 as being unpatentable over Konno '438 in view of Pan '968.

Applicant respectfully suggests that the teachings of Pan '968 cannot be combined with Konno '438 in this manner, and do not achieve the claimed invention.

First, Pan '968 teaches tapering the end of an optical fiber or lens element, to a diameter smaller than the fiber, but not thereafter forming a larger-diameter spherical or aspherical lens element from that tapered end. Nothing in the Konno '438 or Pan '968 references themselves suggest first forming a tapered element as in Pan '968, and then subsequently using that tapered element to fabricate a larger-diameter collimating lens.

Second, Pan '968 and Konno '438 do not teach or suggest an integral lens-fiber assembly in which the lens throat has a diameter that is substantially different than the diameter of the corresponding fiber.

The combination of Konno '438 and Pan '968 are not taught or suggested by the references. Such a combination is the product of using Applicant's disclosure as a template, and therefore involves impermissible hindsight. Even if combined, the references fail to achieve the invention as claimed. As such, Konno '438 and Pan '968 are not believed to render claim 22 unpatentable.

Claims 23 and 24 have been rejected as under 35 USC §103 as being unpatentable over Konno '438 and Pan '968 in view of Miller '653.

As discussed above, Miller '653 is not believed to be an analogous reference, and further does not teach or suggest the use of a borosilicate glass or particularly a 4 wt% borosilicate glass in fabricating an integral lens-fiber assembly. Its combination with Konno '438 and/or Pan '968 is not supported by the references themselves, and does not achieve the invention as recited in claims 22 or 23 for the same reasons discussed above.

Applicant respectfully requests that the rejections under §103 based upon the Konno '438, Miller '653, and Pan '968 patents should be withdrawn.

3. Allowable Subject Matter and New Claims

Applicant notes the Examiner's allowance of the subject matter of claims 14-17 with appreciation. Claims 14-17 have been canceled, and the corresponding subject matter recited in new claims 42-45, with claim 42 being independent in form. Claims 43 and 44 have been revised relative to claims 15 and 16 to ensure greater clarity in those claims.

New claims 46-53 have been added. Claim 46 is directed to the assembly comprising an optical waveguide and lens member in which the diameter or cross-sectional dimension of the throat portion differs significantly from the diameter of the optical waveguide. Claims 47-49 recite the subject matter of the glass used to form the throat portion of the lens member having a softening point less than that of the core of the optical waveguide, and in particular being a borosilicate glass and a 4 wt% borosilicate

glass. Claims 50-53 recite embodiments in which the difference in diameter is 8% or 10 microns (using a 125 micron diameter optical waveguide as a reference for percentages) and 60% or 75 microns (using the same 125 micron diameter optical waveguide), which are therefore numerically commensurate with examples provided in the specification and recited in claims 5 and 6.

4. Conclusion

Claims 1-13 and 18-53 are believed allowable over the art of record for the reasons discussed above, and reconsideration of those claims is respectfully requested

Based upon the above amendments, remarks, and papers of records, applicant believes the pending claims of the above-captioned application are in allowable form and patentable over the prior art of record. Applicant respectfully requests that a timely Notice of Allowance be issued in this case.

Applicant believes that no extension of time is necessary to make this Reply timely. Should applicant be in error, applicant respectfully requests that the Office grant such time extension pursuant to 37 C.F.R. § 1.136(a) as necessary to make this Reply timely, and hereby authorizes the Office to charge any necessary fee or surcharge with respect to said time extension to the deposit account of the undersigned firm of attorneys, Deposit Account 03-3325.

Please direct any questions or comments to Philip G. Alden at 607-974-8803.

Respectfully submitted,

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approximately 4.5 mm from the lens surface, implying a 9 mm separation between a pair of collimating lenses having an optical device disposed in between within an optical component.

SUMMARY OF THE INVENTION

One aspect of the present invention is an optical waveguide lens for collimating or focusing a light beam comprising an optical waveguide and a lens member connected to and extending from the end of the optical waveguide, wherein the lens member has a throat portion whose cross-sectional dimension is substantially greater than the diameter of the optical waveguide, and a generally spherical lens portion.

In another aspect, the present invention is an optical waveguide lens including an optical waveguide and a generally spherical lens member, wherein the mode field diameter or beam diameter of a light beam projected from the spherical lens member is greater than 100 μm measured at a displacement from the surface of the spherical lens member corresponding to the beam waist.

A further aspect of the present invention is an optical waveguide lens including an optical waveguide and a generally spherical lens member attached to the optical waveguide, the generally spherical lens being fabricated from a glass having a softening point less than that of the core of the optical waveguide.

In another aspect, the present invention is an optical waveguide lens including an optical waveguide and a generally spherical lens member attached to the optical waveguide, the generally spherical lens being fabricated from a borosilicate glass, and particularly a 4 ~~mole~~ weight percent borosilicate glass.

A further aspect of the present invention is a method for fabricating an optical waveguide lens comprising the steps of providing an optical waveguide, providing a lens blank defining a cross-sectional dimension substantially greater than the diameter of the optical waveguide, fusing the lens blank to the optical waveguide, heating a portion of the lens blank above its softening point, applying tension to the lens blank until it separates to form a segment having a tapered distal end connected to the optical waveguide, and heating the tapered distal end of the lens blank above its softening point such that a spherical lens portion is formed in alignment with the axis of the

28 optical fiber available from Corning Incorporated of Corning, New York, the core 28 is a germania-doped silica.

One glass material which has proven suitable for use as the lens blank 34 in forming the lens member 14 of the optical waveguide lens 10 of this invention is a borosilicate glass, particularly a silica glass doped with 4 ~~mole percent (mol%)~~ weight percent (wt%) of B_2O_3, conventionally referenced as 4 ~~mol%~~ wt% B_2O_3-SiO_2 glass. The borosilicate glass splices well to standard single-mode fibers and other optical waveguides 12, and produces uniform and reproducible lens members 14 with select rates above 90% for a working distance of 4 mm. The use of borosilicate glass improves performance because fusion splicing a silica optical waveguide 12 with a borosilicate glass lens lank 34 causes thermal core broadening (i.e., on the order of 31% for splicing to either SMF-28 or large-effective-area non-zero dispersion shifted optical waveguides 12), which enlarges the mode field diameter and increases the tolerance for lateral misalignment of the optical waveguide 12 to the lens blank 34. Angular alignment must be closely controlled. A comparison of the filament powers used in the fabrication steps described above as between silica, germania-doped silica, and borosilicate glasses is instructive. As one representative example, in the process described above where splicing the optical waveguide 12 to a silica lens blank 34 will require 20-21 watts of filament power or19 watts for germania-doped silica, only 18 watts are required for borosilicate glass. In taper cutting the lens blank 34, the corresponding figures are 26 watts for silica, 24 watts for germania-doped silica, and 21 watts for borosilicate glass. In melt back to form the spherical lens portion 18, the corresponding figures are 31 watts for silica, 26 watts for germania-doped silica, and 24 watts for borosilicate glass. Standard properties of the borosilicate glass include a softening point of 1520 °C, an n_D of 1.457, α of 9×10^{-7} deg^{-1}, an annealing temperature of 999 °C, strain point of 910 °C, elasticity of 9.2×10^{6} psi, α of 4.6×10^{-7} deg^{-1} at the strain point, ln η_0 of –8.793 poise (where η_0 is viscosity at infinite temperature), and Q (activation energy divided by gas constant) of 49520 (K). A plot of viscosity as a function of temperature shows that borosilicate glass has a slope less than that for silica, allowing the use of lower temperatures for fabricating the optical waveguide lens 10 of the present invention.

Referring to Figures 16-18, a method for mounting the optical waveguide lens 10 of the present invention in a ferrule 42 is shown. The ferrule 42 may be any

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FIG. 19

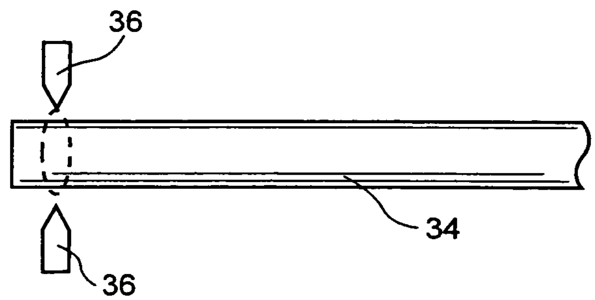


FIG. 20

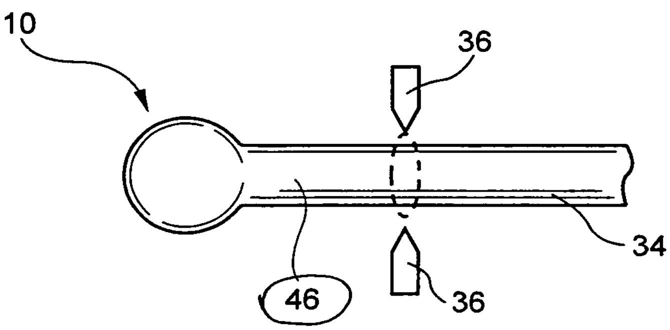
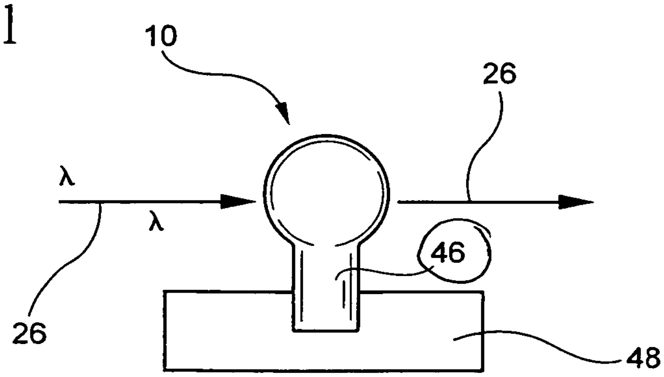


FIG. 21



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